Solar Observation Project

Instructions

Over the course of the semester, you will collect data to test the following hypothesis:

**H1:**  We expect to observe that shadows cast by object in sunlight at midday will grow longer from September 17th to October 28st, indicating that the angle of the Sun above the horizon at midday has decreased over the course of the measurement period.

Your grade for the project will be divided between data collection (6 points) and a final report (4 points). You will collect data on the position of the midday Sun using the data collection worksheets three times during a six-week period. You will have two-week windows in which to collect each of the three sets of measurements:

|  |  |  |
| --- | --- | --- |
| Observation Window #1 | September 17th – September 30th  | Due: 10/1; before 9:30 AM |
| Observation Window #2 | October 1st – October 14th  | Due: 10/15; before 9:30 AM |
| Observation Window #3 | October 14th – October 28th  | Due: 10/29; before 9:30 AM |

You are required to measure the position of the midday Sun on one day during each of the three observation windows. A *Midday Sun Angle* worksheet is due before 9:30 AM on the day after each window ends (i.e., Worksheet #1 is due October 1st, Worksheet #2 is due October 15th and Worksheet #3 is due October 29th). ***No late work will be accepted***. You are encouraged to submit your worksheet any time during its observation window (e.g., if you collect your first data collection on September 17th, you can hand in the first observation worksheet any time before 9:30 AM on October 1st). Either hand me the worksheet during your class or lab meeting or slide the worksheet under my office door.

It is absolutely essential that each student collect data from each observation window. If a student submits only 2 of the 3 required data collection worksheets, the penalty will be half of the possible data collection points (3/6). A second missing data point will result in a grade of zero (0/6) for the data collection portion of the project.

You may work in groups of up to four students on the data-collecting portion of this project only. Each group will turn in one worksheet. All students in the work group must sign the worksheet to get credit for that data submission. Each *student* is individually responsible for all data submitted. If falsified data are submitted, ***all*** students who signed the data collection worksheet will receive a grade of zero for the entire Solar Observation Project (0/10) for academic misconduct. Each *work group* is responsible for collecting its own data, and separate work groups may **NOT** work together on data collecting. Two or more work groups who turn in significantly similar worksheets will all be assessed a grade of zero for that worksheet. You are not stuck working with any group; at any time, you may choose to switch work groups or work alone. I will not referee group dynamics.

Please keep in mind that cloudy weather can make observing the midday Sun impossible on some days, which is why you are given a two week window in which to make each observation. Completing the data collection worksheet can be a little tricky the first time, so please do not wait until right before class on the due date to complete the data collection worksheet. Your professor will not be available to help you during that time. Please either come to my office hours or make an appointment if you would like help with the calculations.

Data Collection Procedure

You will observe the shadow cast by an object of known height at midday and use that data to determine the position of the Sun in the sky relative to the horizon. Please use the *Midday Sun Angle* worksheet to record all of your data, including information about your chosen object. Choosing an appropriate object is very important. The object you chose must meet ***all*** of the following requirements:

1. It must be on the main Winthrop University campus.
2. It must be permanently attached
3. It must be non-living
4. It must be exposed to the midday Sun in such a way that the object casts a clear shadow onto reasonably level ground.
5. It must be ***at least*** 150 cm tall.

If there is some reason you can’t use an object on Winthrop’s campus for this project, please talk to me about choosing a different object. Whatever object you chose, please use the same object for all three measurements unless it becomes impractical for some reason. You must include enough information in the “Description of Object” box on the *Midday Sun Angle* worksheet for another person to find your chosen object. Taller objects are preferable, as long as you can measure the object’s height accurately. Measure the height of the object to the nearest centimeter, and record that data on the *Midday Sun Angle* worksheet.

Each observation must be made when the Sun is at or near its highest point in the sky for that day. For a number of reasons, “midday” in Rock Hill does not correspond to noon on the clock (e.g., Daylight Savings Time, the position within the Eastern Time Zone and the speed of Earth’s orbit). Table Two lists the times for “true” midday in Rock Hill for each potential observation day. You must collect data within 15 minutes on either side of the true midday time on the day you collect your data.

**Table Two:** Midday times for potential observation days in Rock Hill, South Carolina as reported by the U.S. Naval Observatory Astronomical Department (http://aa.usno.navy.mil/) fro Rock Hill, York County, South Carolina (Longitude: W81.0, Latitude: N34.9)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Observation Window #1 | Midday Time |  | Observation Window #2 | Midday Time |  | Observation Window #3 | Midday Time |
| 9/17 | 1:19 PM |  | 10/1 | 1:14 PM |  | 10/15 | 1:10 PM |
| 9/18 | 1:18 PM |  | 10/2 | 1:13 PM |  | 10/16 | 1:10 PM |
| 9/19 | 1:18 PM |  | 10/3 | 1:13 PM |  | 10/17 | 1:09 PM |
| 9/20 | 1:17 PM |  | 10/4 | 1:13 PM |  | 10/18 | 1:09 PM |
| 9/21 | 1:17 PM |  | 10/5 | 1:12 PM |  | 10/19 | 1:09 PM |
| 9/22 | 1:17 PM |  | 10/6 | 1:12 PM |  | 10/20 | 1:09 PM |
| 9/23 | 1:16 PM |  | 10/7 | 1:12 PM |  | 10/21 | 1:09 PM |
| 9/24 | 1:16 PM |  | 10/8 | 1:12 PM |  | 10/22 | 1:09 PM |
| 9/25 | 1:16 PM |  | 10/9 | 1:11 PM |  | 10/23 | 1:08 PM |
| 9/26 | 1:15 PM |  | 10/10 | 1:11 PM |  | 10/24 | 1:08 PM |
| 9/27 | 1:15 PM |  | 10/11 | 1:11 PM |  | 10/25 | 1:08 PM |
| 9/28 | 1:15 PM |  | 10/12 | 1:11 PM |  | 10/26 | 1:08 PM |
| 9/29 | 1:14 PM |  | 10/13 | 1:10 PM |  | 10/27 | 1:08 PM |
| 9/30 | 1:14 PM |  | 10/14 | 1:10 PM |  | 10/28 | 1:08 PM |

Record the exact time and date of your observation on your *Midday Sun Angle* worksheet. Measure the length of the object’s shadow to the nearest centimeter and record that data on your *Midday Sun Angle* worksheet. You now have all of the data you need to complete the calculations on the worksheet.

Calculating the Midday Sun Angle

You will use two techniques to determine the angle between the midday Sun and the horizon:

1. The geometric graphical method will allow you to determine a rough estimate of the angle using the diagram at the bottom of the *Midday Sun Angle* worksheet. The y-axis represents the object casting the shadow. Determine the shadow length on the x-axis to scale by calculating L/H and plot that point on the graph. You should now have a graphical representation of the relative positions of the object and its shadow. To determine the midday Sun angle, use a straightedge to draw a line from the end of the shadow on the x-axis to the top of the object on the y-axis. Use a protractor to determine the midday Sun angle based on the diagram.
2. The trigonometric method allows you to determine the midday Sun angle more accurately than the graphical method. Figure One is a graphical representation showing the trigonometric relationship between the midday Sun angle and the right triangle with the object height and shadow length as the two legs adjacent to the right angle. Calculate the midday Sun angle by dividing **H** by **L** and then applying the **ArcTan** function (**Tan-1** on most calculators) to that value. The default setting on most calculators is radians, not degrees, so be sure that your answer is in degrees, not radians. If you prefer Excel, here is the setup (your answer will pop up in box C2 if you enter your data in A2 and B2 and the equation as written in C2):

|  |  |  |  |
| --- | --- | --- | --- |
|  | A | B | C |
| 1 | object\_height | shadow\_length | Midday Sun Angle |
| 2 | 150 | 200 | =DEGREES(ATAN((A2/B2))) |

**Figure One:** Trigonometric relationship between object height (H), shadow length (L) and the midday Sun angle (theta)



If the two calculations are not reasonably similar (within a few degrees), then you have made an error somewhere. The midday Sun angle in degrees will not be greater than 78o or less than 32o, so if one of your calculations falls outside that range, there is a major error in your calculations or measurements. If you run into trouble with these calculations, please come and see me during my scheduled office hours or make an appointment to meet at some other time. Please do not plan to ask me to help you on the morning that the worksheets are due – I will not have time to help before class. Plan ahead!